

# Accelerator Simulations Cluster

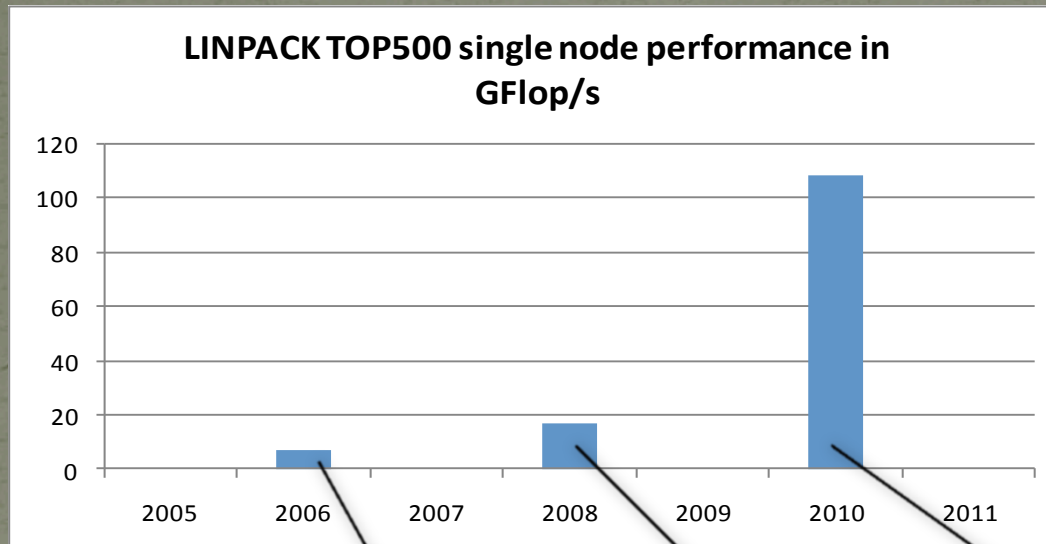
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Jim Simone, Amitoj Singh

High Performance & Parallel Computing  
Computing Division



# Brief history of past & present clusters



## **CPA Cluster**

19 nodes  
2 cores / node  
Xeon 3.2GHz  
2GB memory/  
core  
Infiniband 10  
Gbps

## **RFSIMS Cluster**

20 nodes  
4 cores / node  
Xeon 2.3GHz  
4GB memory/  
core  
Ethernet 1Gbps

## **Wilson Cluster**

24 nodes  
12 cores / node  
Xeon 2.67GHz  
1GB memory/core  
Infiniband 10  
Gbps





# The Wilson cluster

- Joint acquisition by CD, CPA (AMR) and TD (SRFD) groups at a total cost of \$90k.
- An oversight committee consisting of members from each stakeholder group ensures the proper and efficient use of cluster resources. Committee members include:
  - CD                      Jim Amundson (chair)
  - APC                     Alex Valishev
  - TD                        Andrei Lunin
- CD's HPPC department is in charge of the daily (5 days, 8 by 5) administration and maintenance of the cluster.
- More information on the cluster is available @ <http://tev.fnal.gov>



# Wilson cluster details

## Hardware

- Total 24 nodes (288 cores) deliver **2.3 TFlop/s** on the Top500 benchmark
- 2-socket, 6-core Intel Xeon *Westmere* 2.67 GHz (12 cores per node)
- 12GB DDR3 memory per node
- 2 Gigabit Ethernet controllers
- 1 SDR (10 Gbps) Infiniband HCA



## Major applications run on our clusters

**Analyst** - Parallel FEM-EM (Finite Element Method-Electro Magnetic) solver.

**ANSYS HPC** – Multi physics parallel processing.

**GAMESS** - General Atomic and Molecular Electronic Structure System for a wide range of quantum chemical computations

**Gdfidl** – Electromagnetic field simulator computes electromagnetic fields in 3D-structures.

**Synergia** – Accelerator physics modeling framework.

**VASP** – Vienna Ab-initio Simulation Package for performing ab-initio quantum-mechanical molecular dynamics using pseudo potentials and a plane wave basis set.

## Software & Batch Queue System

OS:

SLF 5.5

Compilers:

gcc

OpenMPI

Infiniband:

OFED

Programming:

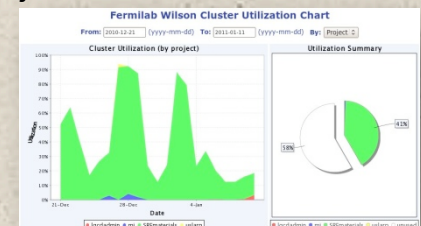
Python

R

Ruby

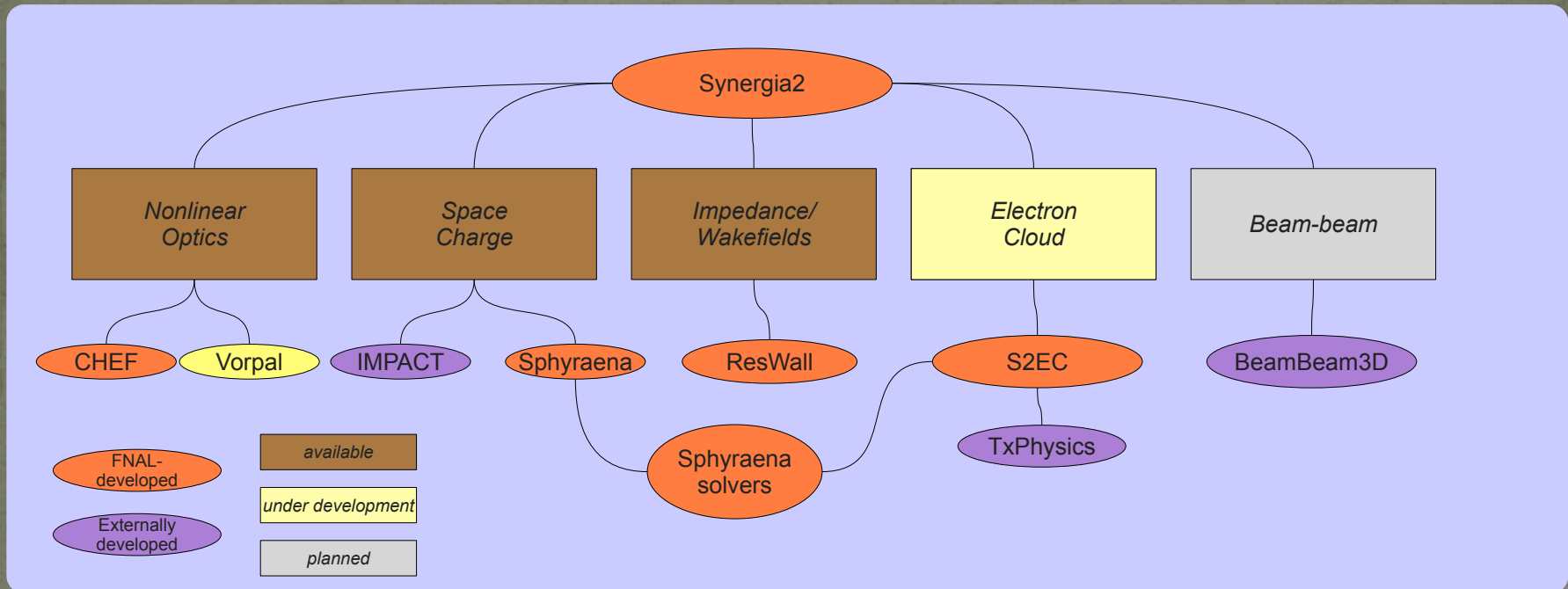
3 batch queues for **default**, **low** and **high** priority jobs.

Users required to provide a project name to submit jobs. Cluster usage available by project and user.





# Accelerator Simulations on the Wilson Cluster



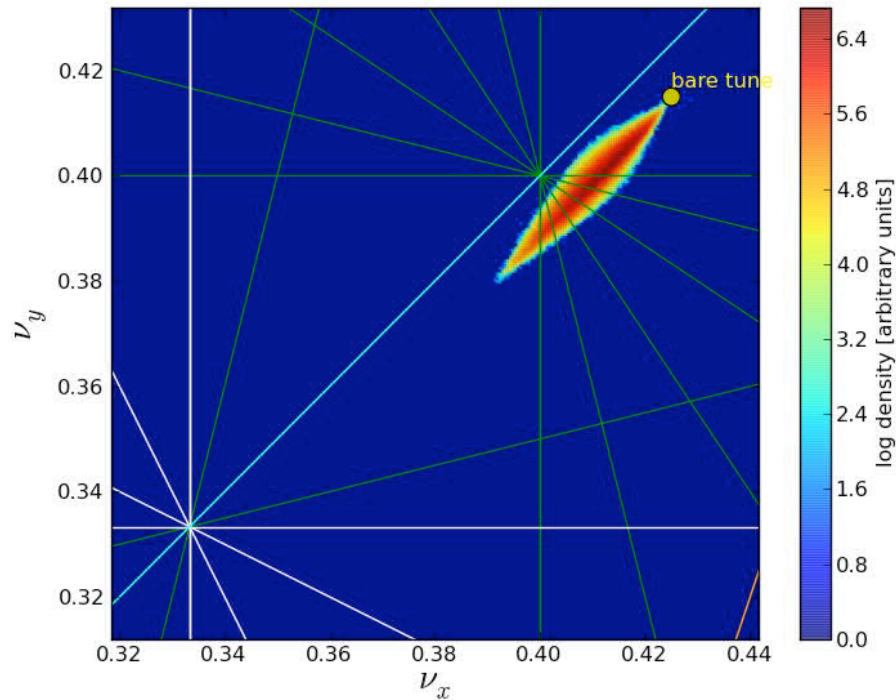
- Nonlinear single particle optics
  - accounts for higher order multipoles and fringe fields
- Collective effects
  - space charge and impedance solvers rely on infiniband network for multiprocessor calculations



# Main Injector Space Charge for Project-X

The Main Injector will be the workhorse of the Project-X high energy high-intensity physics program

Tune footprint, 2000 turns current  
MI running conditions



MINOS and Nova neutrinos to  
Soudan mine and Ash River (MN)

LBNE neutrinos to  
DUSEL (SD)



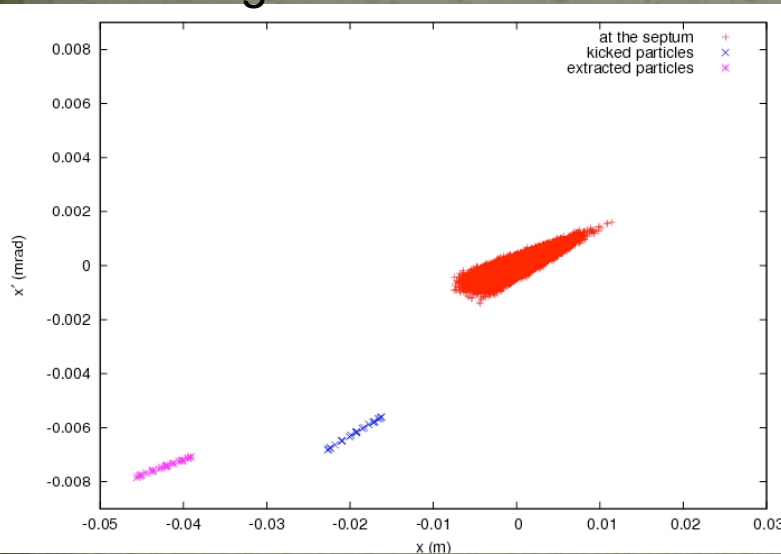
Even with current conditions,  
space charge spreads the tune  
footprint over a large area.  
Increased intensities will  
require corrective actions which  
will need to be simulated.



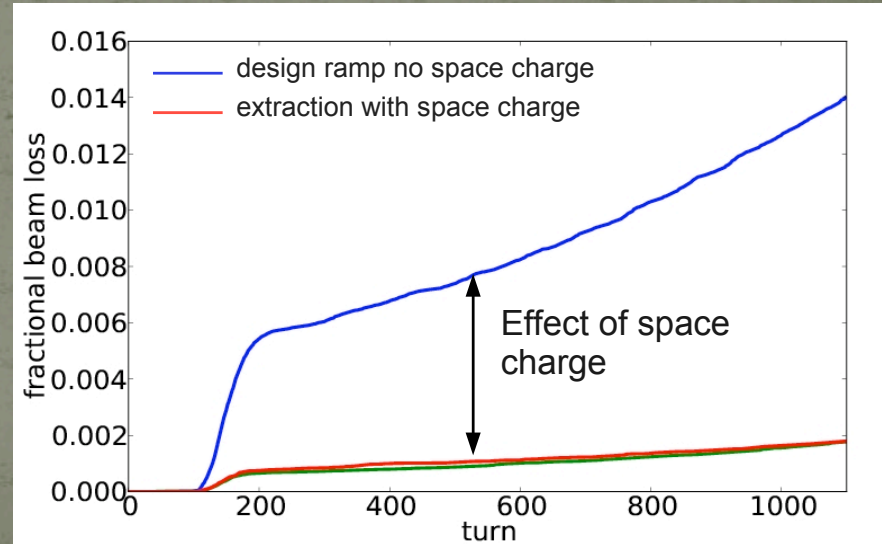
# Space Charge in Resonant Extraction for Mu2e

The proposed Mu2e experiment plans a slow resonant extraction of a beam with  $3 \times 10^{12}$  protons from the debuncher ring. Space charge significantly effects the extraction procedure.

Phase space of particles through extraction



Simulation of particles extracted



Space charge effects force reworking the magnet ramp profile

E. Stern